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NOTE *— This Journal offers prizes for the best studies of tornadoes. Competition closes July 1st, 1889. For particulars send to Mr. Harrington, at Ann Arbor, for special circular.*

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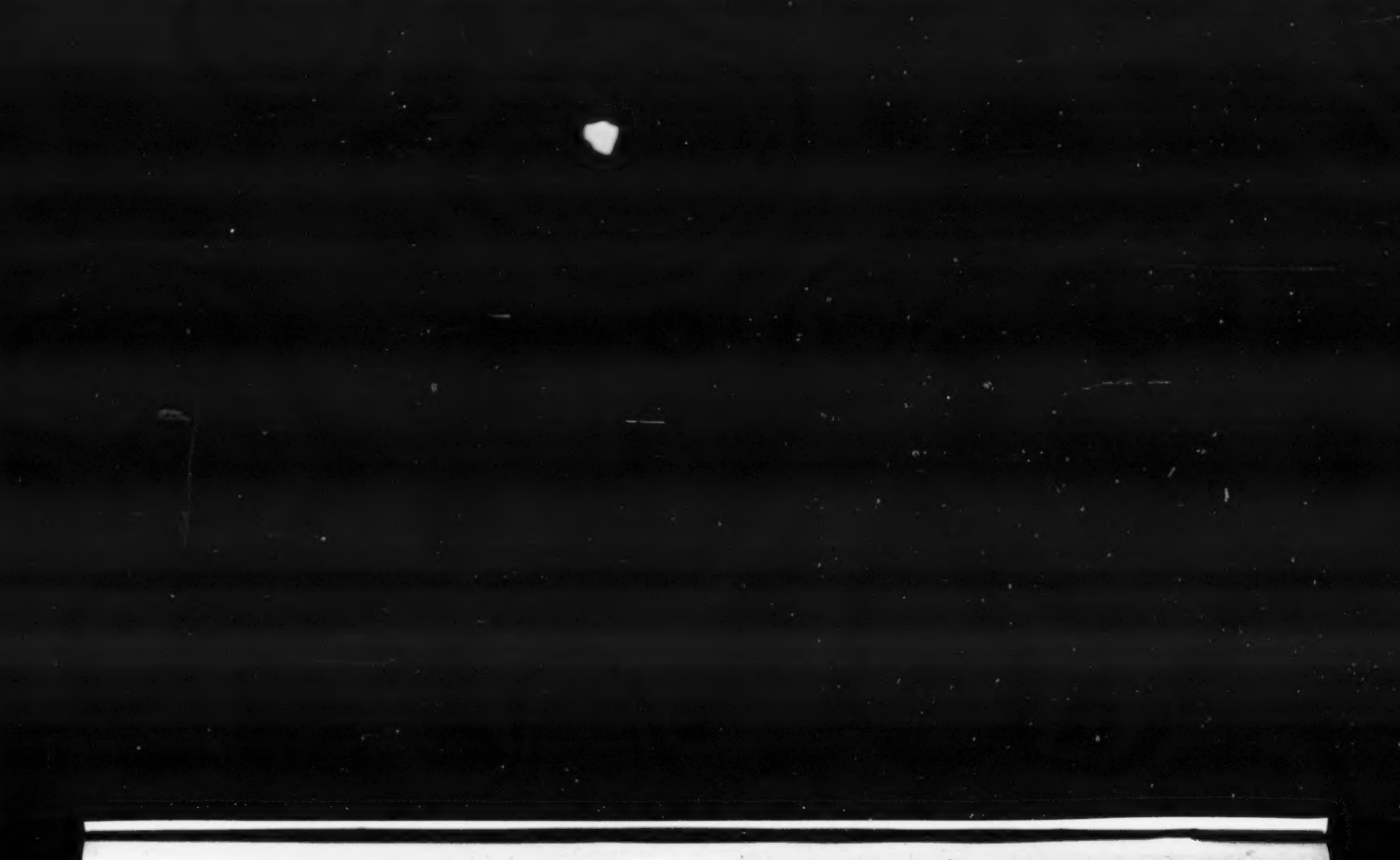

THE AMERICAN
METEOROLOGICAL JOURNAL.

VOL. V. ANN ARBOR, MARCH, 1889. NO. 11.

ORIGINAL ARTICLES.

THE ORGANIZATION OF THE METEOROLOGICAL SERVICE IN SOME OF THE PRINCIPAL COUNTRIES OF EUROPE.

BY A. LAWRENCE ROTCH,

Member of the German Meteorological Society, and Fellow of the Royal (London) Meteorological Society.

THE METEOROLOGICAL OBSERVATORIES IN PARIS.

THE PARIS OBSERVATORY.

This institution was until 1877 the National Observatory and the headquarters of the Weather Service of France under Le Verrier, as has been before mentioned, but its interest from a meteorological point of view is now chiefly in its long series of observations.

The temperature observations date from 1666, but it is impossible to have precise data before 1671, when Cassini established his instruments. The thermometers of the time were very imperfect, so that it is difficult to deduce from these early observations mean values which are comparable with those of to-day. The first thermometer was the alcohol one of La Hire, which was hermetically sealed and fastened to the wall of the open eastern tower of the Observatory, where it was protected from wind and sun. It was observed from 1669 to 1754. While La Hire was making his observations, Cassini was using a Fahrenheit thermometer placed at the north window of the east

tower, 25 feet above La Hire's. This thermometer was observed from 1682 to 1705, and read 55° (12.7° C.) in the Observatory cellars when first set up, and 54.7° (12.6° C.) 20 years later. From 1706 to 1732 Amonton's thermometer was employed, but there are many gaps in these observations. From 1732 to 1750 the thermometers of La Hire and Reaumur were placed side by side and gave the cellar temperature as 12.8°. An alcohol Reaumur thermometer was read from 1750–56, and a mercurial one from 1763–78. The latter instrument gave the cellar temperature as 11.1°, and from numerous comparisons read 2° lower than the alcoholic thermometer. New thermometers of Mossy were installed in 1782 and 1792, the last one giving the cellar temperature as 11.6°. The French Revolution caused numerous breaks between 1787 and 1803, but from 1804 to the present time the observations have been regularly maintained, and the thermometer used by Arago is now exposed in a metallic screen outside a north window of the east tower, about 25 feet from the ground. Self-registering thermometers were first used in 1835; up to this date the minimum temperatures were taken as the readings at sunrise and the maximum readings as those at 3 P. M.

The extremes of temperature during the long period are —23° and 40° C. From the annual extremes it appears that the warmest summers occurred in the middle and last half of the past century, and that the coldest winters were spread over a little later period. The mean temperature, deduced from 96 years, is 10.7° C. which coincides nearly with the temperature of the Observatory cellars, 29 m. below the courtyard, assuming that there was an increase of one degree at this depth. These observations do not form a sufficiently long series to prove that the climate is undergoing a permanent change, or that it is only acted upon by temperature oscillations of long period.

The first pluviometric observations were made at the Paris Observatory in 1689 by La Hire. The gauge which he used was placed on the east tower and was connected with the receiver by a tube 21 m. long. This bad arrangement was not modified until 1803 when a new gauge having a diameter of about 50 cm. was placed on top of a winding staircase leading to the terrace, 28

m. above the ground. The cock is locked, which allows the water to run into the glass graduated to hundredths of millimeters. This gauge is still in use, but in winter its indications are not reliable. In 1817 another gauge was placed in the northwest portion of the courtyard, and is still employed. It has a diameter of about 75 cm. and its mouth is about 2 m. above the ground. It is enclosed by a wooden case, and in winter a stove melts the snow. Some poplar trees planted in 1854 to the east of the gauge, which affected the quantity of rain caught by it, have recently been cut down. The ratio between the amounts of rain collected by the two gauges is about 1.13 more for the courtyard gauge, but during the last few years, owing to the growth of the trees diminishing the circulation of the air in the courtyard, while the conditions affecting the terrace gauge remained nearly the same, the ratio became less. The indications of the terrace gauge are on the whole considered as more comparable.

From statistics of the rainfall from 1688 to 1871 it appears that the wettest year was 1804 with a fall of 703 mm., and the driest 1733 with 210 mm. The driest period was from 1718 to 1747, the wettest period from 1733 to 1788. After this in decreasing amounts came the periods 1849 to 1871, and 1819 to 1848. In the present century the winter rains have been diminishing from 1804–1818 until the present time, while the summer rains, on the contrary, have been increasing.

Observations of the declination of the magnetic needle, made in the same locality, extend over 205 years with many breaks, having been commenced at the Paris Observatory by Picard in 1667. Since 1806 the compasses of Lenoir and Gambey have been in use. The declination has varied as follows: In 1580 it was east of the true north with which it coincided in 1663, then, continuing its movement to the west, it reached a maximum of 22° W. about 1814, and fluctuated around this figure until about 1825, since which time there has been a retrograde movement towards the east, and the present value is about 17° W. The inclination of the magnetic needle has not been so regularly measured, but since 1671 it has been constantly diminish-

ing in amount. A series of vaults constructed a few years ago, 6 m. underground, are so damp that notwithstanding methods of drying and ventilating they cannot be used. In 1871 the magnetic instruments were transferred to the Montsouris Observatory.

The only registering apparatus at the Paris Observatory are the Bourdon and Seyrig anemometers. The former, installed in 1883, is an aspiration anemometer in which the suction produced by the wind blowing through a horizontal Venturi tube acts on a vacuum-box and registers its velocity in meters per second and its direction upon a band of paper. The other instrument is a wind-pressure gauge whose plate acts against a spring and registers upon a drum turned by clockwork the force of the wind.

Meteorology has been neglected at the Paris Observatory since the establishment of the Central Meteorological Office in 1878. Its present director is Admiral Mouchez.

THE MONTSOURIS OPSERVATORY.

History.—This Observatory was founded in 1871 by the Minister of Public Instruction, through the influence of the scientists, MM. A. Dumas and Ch. Ste-Claire Deville, with the general aim to make researches upon growth and health as affected by the changes of weather and the composition of the air. It is managed by a Commission whose president and the first director, M. Ste-Claire Deville, was succeeded by M. Marié-Davy. For a short time the Montsouris Observatory was attached to the Paris Observatory, which at that period was the headquarters for weather telegraphy.

Hygienic observations, commenced in various parts of Paris in 1876, were placed under the supervision of the Montsouris Observatory, and in 1879 the municipal authorities put at its service a tract of land at Gennevilliers for the study of sewage questions. In 1884, an auxiliary station was established in the centre of Paris, for the collection of hygienic data. From January 1, 1887, the Montsouris Observatory ceased to belong to the state and became a municipal station. At the same time,

the director, M. Marié-Davy, resigned and his place has not been filled. The three distinct services: meteorology, terrestrial magnetism and the physics of the atmosphere; chemistry of the atmosphere and meteorology applied to agriculture; and the micrography of the atmosphere; have their respective chiefs.

The Observatory.— It is located in the Park of Montsouris, adjoining the fortifications, in the southern quarter of Paris, which it overlooks. About two hectares are enclosed for the Observatory, which occupies the highest point of the Park at an elevation of 79 m. Unfortunately, the Sceaux and Belt railways pass through the Park and intersect only 200 m. from the Observatory, and these must affect the magnetic observations. The main building, in which formerly lived the director and his family, is an imitation of the palace of the Bey of Tunis, serving as a coffee-house at the Paris Exposition of 1867, and is not adapted to the purpose of an observatory.

The Meteorological and Magnetic Instruments and Observations.— The work of the meteorological department, including atmospheric electricity and terrestrial magnetism, consists in direct eye observations, generally made every three hours from 6 A. M. to midnight, serving also to control the curves traced by the self-recording instruments, and in the discussion of the results from a meteorological and agricultural standpoint.

The barometers are placed in a covered court-yard. The normal siphon barometer of Salleron is read by an attached cathetometer to .002 mm. A Tonnelot-Renou closed cistern barometer, with a capacity correction for the change of level of the mercury in the cistern, is in current use, as are the recording barometers of Redier and Salleron. In the latter the barometric tube is fixed, and has at its lower extremity a cylindrical plunger. The cistern is suspended to one end of the beam of a balance, the other end of which carries a counterpoise. When in consequence of a rise of the barometer, a part of the mercury rises from the cistern into the tube, the former thus rendered lighter, tends to rise, with the effect of introducing into the mercury of the cistern a greater length of the cylindrical plunger. Equilibrium is only reëstablished when (the volume

of mercury displaced by the plunger being equal to that which corresponds in the tube to the increase in height of the barometric column) the level of mercury in the cistern returns to its constant point, and when, consequently, the apparent weight of that cistern has resumed its fixed value. The needle of the beam of the balance marks its displacement on the smoked paper of a cylinder revolved by clockwork. The armature of an electro-magnet carries an arm with a steel point which traces on the cylinder a datum line from which the ordinates of the barometric curve are measured; but every hour the electro-magnet is acted upon by a clock marking the time on all the registers, and the point makes a stroke which is reproduced at the same instant on the other cylinders. At the end of the week the cylinder is removed, to be replaced by another, and is placed on the micrometric apparatus to have the curve reduced to figures. This consists of a bench with supports for the axis of the cylinder, and of a stand with two microscopes which may be moved either separately or together in a horizontal direction. By means of an endless screw, a movement of rotation on its axis may be given to the cylinder for the purpose of presenting successively to the microscopes the various faces of the cylinder. One microscope is always pointed to the datum line, and at each hourly reading one of the horizonal traces on the datum line is brought under the horizontal thread of the microscope. A second horizontal thread is movable by a micrometer screw, and serves to divide the hours. The other microscope is supported at the extremity of an arm of a lever, the length of which is equal to that of the barometric and other needles. Tha first microscope being directed to an hourly mark, the axis of the second is pointed to the corresponding point of the curve. The sine of the angle of position of its lever, multiplied by a constant factor and increased by a constant, gives the height of the barometer. When the reading of the curve is made and verified the sheet of blackened paper is taken off the cylinder and soaked in a solution of gum lac in alcohol, which "fixes" the curve, and it may then be filed away. The records of the other instruments are treated in the same way.

In the garden among trees is the thermometer shelter of Ste-Claire Deville. It is essentially the same as that at the Park of St. Maur, except in its construction of iron. Under it, at a height of 2 m. from the ground, are the usual thermometers and the registering thermometer and hygrometer of Richard. Comparisons of the shelter with the Kew and Greenwich screens and with a sling thermometer showed but small differences. Under the shelter, also, are an evaporimeter, or atmometer, and two hair hygrometers. The Piche evaporimeter is an inverted graduated test tube, filled with water, and its mouth closed by a disk of filter paper held by a spring. The Eichen's hygrometer has a 15 mm. long hair stretched by a fine wire and enclosed in a tube. The alteration in length of the hair is read by a microscope to 0.1 mm. In the Salleron hair hygrometer, equal amounts of humidity correspond to equal divisions on the arc over which the needle moves.

Maximum and minimum thermometers are placed over sod and at distances of 0.02 m., 0.10 m. 0.20 m. and 0.30 m. under it. The standard actinometer consists of two black and bright bulb thermometers *in vacuo*, placed 2 m. above the sod and read twice daily. Special attention has been given to actinometry at Montsouris, and it is proposed to render comparable the indications of instruments in various places by determining a constant for each instrument, after which the actinic degree can be calculated by the formula of Bouguer. Another actinometer, based on that of Bellani, has a blue bulb *in vacuo*. This bulb contains alcohol, which is vaporized by the sun's heat and condensed in a graduated tube. The amount of condensation is measured daily and represents the total solar radiation approximately.

The thermograph has seven needles recording on one cylinder, composing three distinct instruments: psychrometer, earth thermometer and actinometer. One needle traces the datum line and time scale. The motor of the thermograph is a Bourdon tube of copper with an elongated elliptical section twisted into a spiral. This tube is filled with alcohol under pressure and closed at its two ends, one of which is fixed, so that

the expansion of the alcohol compels it to untwist and the free end of the tube bears the needle which registers. The psychrometer is formed of two twisted tubes placed outside, and perpendicular to the north face of the wooden kiosk which shelters the cylinder. Their furthest extremity is fixed, the other is prolonged through the walls of the kiosk by a stem of copper carrying the registering needle. One of the twisted tubes is uncovered, and forms the dry thermometer; the other is covered with cambric and kept moist by means of cotton wicks dipped in small glass cups connected by a rubber tube, with a Marriotte flask inside the kiosk. The indications of this apparatus are controlled by eye observations of mercurial thermometers, similarly exposed under a zinc roof and screened by blinds on the east and west sides. A modification of Klinkerfuess' hygrometer, constructed by Richard brothers, has lately replaced the wet and dry Bourdon tubes, with the advantage of operating in winter. In this instrument a bundle of human hairs acts at an obtuse angle upon a lever which traces the curve of relative humidity upon a revolving cylinder. The earth thermometer is composed of two parts: a thermometric reservoir of black copper is placed on the surface of a mass of vegetable mould, whose top is flush with the platform on the roof of the kiosk; this reservoir communicates by a capillary tube of copper with a twisted tube placed in the kiosk under the cylinder of the register. When the temperature of the ground rises, a portion of the alcohol passes from the upper reservoir into the twisted tube, the pressure increases and the tube untwists; but the twisted tube itself, and its copper capillary tube, are themselves acted on by the variable temperatures which complicate the results. A second twisted tube, similar to the first, provided with its capillary tube, serves to give the necessary corrections. The two twisted tubes arranged parallel to each other in a trough filled with a solution of glycerine and water and the two capillary tubes are soldered to each other throughout their length. The two needles trace two curves, one very slightly sinuous, and the other very undulating. The differences of their ordinates give the temperatures of the ground exposed to the sun during

the day, to nocturnal radiation during the night, to rain and evaporation. The actinometer is also composed of two twisted tubes, resting parallel to each other in the above mentioned trough, and of two capillary tubes. To each of these tubes corresponds a reservoir placed on the roof of the kiosk, and inclosed in an exhausted envelope of glass. One of the reservoirs is silvered, the other is blackened. Placed symmetrically at a little distance from each other, and far from any shelter, they give the same indications during the night, but during the day the black thermometer registers higher than the white one. The difference of the ordinates of the curves traced by the two needles serves to measure the actinic degree. This apparatus has been damaged by fissures appearing in the twisted tubes, and an actinometer constructed by Richard brothers, has been tried. A black and bright ball each communicate with a thermometric tube, and a second short tube neutralizes the effect of variations of temperature on the first, so that the instrument registers only the changes of temperature in each globe.

The totalizing rain-gauge of Hervé Mangon, 2 m. above the ground, is employed, and in winter the method of taking a section of snow is adopted. The registering rain-gauge of Breguet has its receiver upon a post 1.8 m. above the ground, communicating with a cylinder by a subterranean tube about 9 m. long. A piston in the cylinder by means of a rack and pinion turns a cam, and this operates a lever which inscribes the rainfall upon a blackened drum, revolving on its axis in forty-eight hours. This instrument is inoperative during snowfalls, and is then supplemented by the atmograph. This is another registering instrument, intended to mark the variations of weight of a mass of earth whose surface is flush with the roof of the kiosk and is exposed to the sun, to evaporation, to rain, snow and dew. At a little distance is the registering rain-gauge. The comparison of the two curves shows what becomes of the water which falls on the bare earth, distinguishing between what returns to the atmosphere by vaporation and what penetrates the sub-soil which is permeable or drained. Another atmograph gives similar indications for a soil covered with various plants. Both

these instruments, made by Richard brothers, consist of a balance with the platform above, carrying the earth or the plant of which the evaporation is to be measured; the needle of the balance registers its movements either directly or by the intervention of another lever upon a blackened and rotating cylinder. A bottle serves to catch any overflow from the vase containing the earth, and a plunger in mercury to diminish the oscillations caused by wind, which are, nevertheless, very perceptible.

The anemometer consists of a set of Robinson cups for the velocity of the wind and a vane with double fans for its direction, exposed on top of a mast 18 m. high. The anemograph of Salleron gives the direction of the wind and its mean rate per hour. Eight electro-magnets communicating electrically with the sectors arranged in the vane according to the eight principal points of the compass, can by acting singly, or two and two, record the winds for sixteen directions. A ninth electro-magnet is acted on each time that the Robinson cups show a distance of 1 km. travelled by the wind. The point which marks the velocity then advances 1 mm. horizontally. This action is produced during one hour; at the end of this time the needle of the clock establishes an electric contact, and the metallic point is restored to its starting point. The maximum velocities of gusts of wind are furnished by the apparatus of Hervé Mangon, in which each time that the wind has travelled 500 m. the magnet marks a point on the band of paper which is unrolled uniformly by clockwork. The direction of the upper currents, as indicated by the cirrus clouds, is obtained by noting the motion of their images in a mirror whose circumference is divided in sixteen parts.

Atmospheric electricity is collected either in the Thomson system, by a jet of water, to which in winter glycerine is added, or, for irregular observations, by the combustion of a fuse made of paper, impregnated with nitrate of lead and exposed on an isolated point. In the main building are the electrometers. The Branly-Thomson has the upper ebonite plate replaced by glass, and the movements of the needle are read by a telescope furnished with a scale. Observations are made each three hours

during the daytime. The indications of a similar double electrometer—one instrument being ten times more sensitive than the other—can be registered photographically by the Salleron apparatus. By means of prisms and lenses, the light from a gas jet falls on the mirrors of the quadrant electrometers and is reflected upon a cylinder covered with sensitized paper, which turns in two and a half days. The hours are marked by an electro-magnet which grounds the electrometers for a few minutes at every hour, and thus discharges them and brings the mirrors to zero.

The study of terrestrial magnetism includes the determination of absolute values of declination, inclination and intensity, the observed variations of these elements and their registration by photography. Absolute values of the three elements are obtained with the portable theodolite compass of Brunner placed on stone piers in the Park or in the fortifications of Paris. A chart of the declination in France, revised by MM. Marié Davy and Descroix, was published in 1876. Absolute inclination is also measured by the dip-circle of Brunner. The instruments for eye observations of variation, mounted on stone piers in a wooden octagonal pavilion, in whose construction no iron entered, are a declination and bifilar compass, constructed by Eichens and read by a telescope on a scale, and the dip-circle of Brunner.

Observations of these instruments four times a day control the registration of the declinometer and bifilar magnetometer, which are placed in a vault having a tolerably constant temperature. The registering apparatus is similar to that used with the electrometer. The light from a gas jet after passing through a narrow slit and a lens falls upon a mirror attached to the magnetic needle. On emerging from a cylindrical lens it forms a luminous point upon paper rolled off a drum by clockwork. A datum line is traced on the paper by a spot of light reflected by a fixed mirror, and the hours are marked by automatically interrupting the flow of gas and thereby cutting off the light. M. Descroix proposes to connect the perturbations of the curves traced by the declinometer and electrometer with the move-

ments of cyclones as an aid to weather forecasts, and to show that during seismic disturbances the former instrument is affected.

Staff, Budget, and Publications.— M. L. Descroix directs the department of meteorology, terrestrial magnetism, and atmospheric physics. The other and most important departments are that of chemistry, relating to the chemical analysis of the air and meteoric waters collected, of which M. A. Levy has charge, and the department of micrography, where the microscopic study of the organic dusts held in suspension by the air, and of the meteoric waters, is conducted under Dr. P. Miquel. There are twelve employes in all, of whom three belong to the meteorological, four to the chemical, and five to the micrographical departments. The Observatory formerly received an annual budget of 60,000 francs from the state and city, but this is now reduced to 40,000 francs appropriated by the city, of which 10,000 francs only go to the meteorological department.

The *Annuaire de l'Observatoire de Montsouris* with 1887 reached its sixteenth year of publication. It is an 18mo. volume, issued about the middle of the year whose date it bears, and contains a summary of the meteorological, chemical and micrographic work of the previous year, discussed with reference to agriculture and hygiene, together with a description of the instruments employed and the ancient meteorological data for Paris. A monthly *Bulletin*, containing the detailed hourly observations, was published from 1872 to 1877, and the observations continue to appear weekly in the *Bulletin de Statistique Municipal de la Ville de Paris.* The data are also published monthly in the *Comptes Rendus* of the French Academy.

ANEMOMETER COMPARISONS.

By H. A. Hazen.

It is quite interesting that there have been two recent nearly similar and independent attempts to solve the anemometer problem, one in this country with a whirling arm of 28 and afterward 35 feet, and the other in England with an arm whose extreme

length was 29 ft. A brief abstract of the latter experiments was published in this JOURNAL for July, 1888, p. 142, but a more complete report has just appeared in the *Q. Met. Jour.* for Oct., 1888. It may be well to present some of these later results.

The problem is easily stated, though the solution has been extremely difficult. Nearly all methods of measuring wind movement have given way to the simple cup anemometer devised by Robinson. It has been found that the travel of this anemometer varies with the length of arm and diameter of cup. The problem is to find the ratio between the motion of the wind and that of the centre of the cup, or to find the so-called "anemometer factor." Prof. Robinson decided that in all cases this factor should be 3, and nearly all instruments have used this ratio. Unfortunately, much confusion has arisen from applying the term "anemometer factor" to an entirely different quantity, namely, a term which attempts to exclude a so-called "friction constant." Let w = wind movement and v = travel of the cup centre, then the "anemometer factor" x is,

$$x = \frac{w}{v}$$

We also have more recently,

$$w = a + bv,$$

in which a is the "friction constant," often taken as 1 metre per second (2.24 miles per hour), and b is a second constant erroneously called the "anemometer factor." Substituting the value of v in the first equation, we obtain,

$$x = \frac{wb}{w-a},$$

For the anemometer used in this country, arms 6.72 in. and cups 4 inches, some Russian experiments have shown b equal to about 2.47, and this gives values of x as follows:

w	x
5	4.41
10	3.17
15	2.90
20	2.77
25	2.71

It has been often published that our anemometers which assume x as 3.00, give 20 per cent. too much wind, but we see that

even by these values, our velocities are about right from 10 to 15 miles per hour, and for less velocities they give too little wind, and even at 25 miles the amount would be only 10 per cent. too much. These doubts as to wind results in this country led the Chief Signal Officer to arrange for a few comparisons. It was decided to use a whirling arm of 28 feet. The details of the experiment, which were admirably worked out by Professor Marvin, with the results, will shortly be published *in extenso.*

The first experiments were tried in a large, nearly closed court of the War Department building, about 80 feet square. It was found that the air circulation, even in this court, was sufficient to entirely vitiate the results. It would seem at first sight as though a wind would act uniformly on both sides of the whirler, *i. e.*, a current flowing from east to west would retard the cups at the north part of the whirl, but would accelerate them the same amount at the south part. Probably there were eddies in the court different from a straight line wind, but a still more important consideration was suggested by Professor Marvin, and that is, that any current would act continuously upon an anemometer, and while at two portions of the whirl its action would be neutralized, at the other two-fourths the current would always accelerate the cup motion. This is most important in connection with the English experiments, which were in the open air. After a few trials the apparatus was taken to the large closed court of the Pension Office, which indeed was intended from the first. This court, 290x90x100 ft., forms a most magnificent spot for such investigations. Even here it was found that, in the summer time so many windows were opened, no satisfactory results could be had, except after office hours when all doors and windows could be closed. Several anemometers having different arms and cups were tested. Of the results two are given here, and these without the final corrections.

W	*A*	*B*		
		Washington.	St. Petersburg.	Hamburg.
5	2.82	3.30	4.41	3.83
10	2.76	3.11	3.17	2.97
15	2.69	3.05	2.90	2.77
20	2.62	2.98	2.77	2.68
25		2.89	2.71	2.62

A had 6 in. cups and 5 in. arms.

B had 4 in. cups and 6.72 in. arms.

There are added the results for anemometer *B* computed from Dohrandt's formula determined at St. Petersburg, and also the results from whirling *B* at Hamburg. It will be noticed that anemometer *A* gives quite uniform results at different velocities, as indeed had been suggested by Stow after a few wind comparisons. He states the small anemometers relatively to large ones, move faster at low wind volocities than at high. In reality there seems to be a complicated effect, the larger cups have a greater motive power, but their weight is greater and they seem to stop more easily at low velocities. As the velocity increases the relative resistance of the air is probably slightly less, but then eddies and whirls among the cups tend to diminish the motion.

A comparison of the results of the S. S. cups on the 28 ft. arm with those on arms of 11 ft. at St. Petersburg and Hamburg shows very great discrepancies. At 5 miles per hour the St. P. results show a falling off in the velocity of 35 per cent., and those at Hamburg of 16 per cent. while at 25 miles per hour, the former has 7 per cent. greater velocity and the latter 11 per cent. While the Washington results may have an outstanding error of 5 per cent. at the highest velocity, yet these differences are very great, and it does not seem possible to account for all of them by the short arm of the whirler abroad, though the smallness of the room may have added to the difficulty somewhat.

The recent comparisons in England avoided many of the sources of error in solving this problem by the use of quite long arms for the whirler. There were four anemometers tested, all in the open air. No. 1 was the regular Kew standard, having arms of 24 inches and cups of 9 inches, the spindle was placed horizontal and in line with the arm, the centre of the cups being 29 ft. from the axis of the whirler. This was quite objectionable, as the anemometer can never be used in this way. This practically avoided the effect of air currents due to the wind, but the results cannot be closely applied to a vertical spindle. No. 2

was a so-called "helicoidal anemometer" somewhat like an air meter; the method of the original graduation is not given. It was placed at 28 feet from the axis of the whirler, and as was to be expected the results were more uniform than those from any other instrument, for the reason that it was affected very slightly, if at all, by the free air currents which could operate upon it only at two portions of the whirl, and where they practically balanced each other. Nos. 3 and 4 were anemometers of the ordinary pattern, having cups 4″ and 2½″ and arms 5.8″ and 6.75″, respectively. They were placed on opposite sides of the axis of the whirler, and at 17 feet from it. For fear the cups would be wrenched off, the spindle was inclined to the arm of the whirler. This again was an abnormal position which is never used in the free air, and the results must be unsatisfactory accordingly.

Attempts were made to make the tests in still air, but it is said the wind often amounted to four miles per hour. This would have a tendency to lower the factor for the Robinson anemometers. The effect would be most noticeable at the lower velocities; at ten miles per hour it often diminished the factor by 35 per cent. and even more. The following table will make these points clear.

ENGLISH EXPERIMENTS.

W.	Kew.	4″ Cups.		2.5″ Cups.	
	All.	All.	Still day.	All.	Still day.
7	3.02				
10	2.26	2.06		2.69	
15	2.16	2.43		2.93	
20	2.25	2.54	2.94	3.10	3.63
25	2.12	2.53	2.90	3.00	3.55
30	2.13	2.56	2.69	3.03	3.41
35	2.14	2.66	2.70	3.16	3.43
40	2.13	2.61	2.81	3.08	3.51
45	2.17	2.54		3.01	

It is rather dangerous to enter upon an extended discussion without having more of the details, but the following points seem to be plainly brought out.

1st. At velocities above 30 miles per hour most of the results

(only slightly affected by the free wind) are quite satisfactory.

2d. At less velocities the results are entirely untrustworthy.

3d. Experiments 38–42, in the 4th and 6th columns of the table, seem to have been made on a very still day, and are probably much nearer the true value than any of the others, though there seems to have been an error in the high velocities with the 2.5″ cups.

4th. These experiments seem to show that at velocities above 25 miles per hour the factor is practically constant for these cups here used, and all other results have shown a tendency the same way.

5th. The statement that the factor is nearly constant at all velocities and equals 2.15 for the Kew, 2.51 for the 4″ cups, and 2.96 for the 2.5″ cups is entirely erroneous.

It would seem as though we must make the final comparisons in the free wind, as there must be various eddies and sources of error with a whirling arm which could not be allowed for and which would be absent in the open air. It is plain, however, that we can hope for only relative results in the air unless we can obtain the true air travel by the movement of balloons or other light objects. An approximate value of this motion could be obtained with a carefully tested air meter which has its axis horizontal and in consequence is less affected by free air currents, eddies and other sources of error which render the Robinson anemometer unsatisfactory on the whirler. If we obtain the errors of its graduation we may use it in the free wind and thus obtain its motion. Here again we can hope for relative results only, as we cannot determine all the errors of the instrument; but if we have allowed for all errors induced by the whirler, and the comparisons in the free wind do not agree, we may reasonably conclude that the air meter gives the more accurate result.

Many of the evils of the whirler (which, however, it should be noted, do not amount to more than about 5 per cent. at 25 miles per hour) may be done away by exposing an anemometer under a canvas tunnel on the front of two or three platform cars and running them back and forth over a straight track. Another stationary tunnel and anemometer at each end of the track would

enable us to obtain the wind motion along the track, and all side winds in both the moving and stationary tunnels would be cut off.

It has been suggested that the question of exposure of anemometers side by side in the free wind can never be very satisfactory, and serious errors may result in such comparisons. As a matter of fact, however, such results may be had free from almost all error due to exposure. Stow found differences of only 3 per cent. or 4 per cent. in anemometers widely distributed over a large field, and I have made comparisons between 5 anemometers on a roof in which the diifference rarely amounted to 1 per cent. Anemometers of various sizes have been tested side by side at a height a little more than 20 feet above a roof, and the results are given below:

W.	*A*	*B*	*C*	*D*	*E*
2.5	2.87	3.51		7.51	2 78
5	2.84	3.19	3.46	7.36	2.77
10	2.81	2.94	3.25	7.15	2 80
15	2.78	2.87	3.08	6 97	2.78
20	2 75	2.82	2 93	6.78	2.85
25	2.72	2.73	2.80	6.61	

A and *B* have already been described; *C* had 3″ cups and 6.72″ arms. *D* had a cup, first suggested by Mariott, a piece of tin bent in the middle at an angle of 60°. The length of the side was 4″ and the opening was 4″. It was open at both ends. *E* had conical paper cups 8″ diameter and with the center 6″ from the spindle. In all these and succeeding results *A* is virtually assumed as the standard, and if the exact factor is determined for that or any of the others, the other figures will need slight modification accordingly. Anemometer *D* shows that it has very slight driving power, it has less eddy resistance and less ordinary friction at low velocity; it cannot be regarded, however, as at all serviceable.

In some respects *E* is the most interesting of all the styles compared. The results for different hourly movements were remarkably uniform, and much more so than with any other anemometer. The small range at velocities from 2.5 to 20 miles

per hour shows the possibility of constructing an anemometer which shall have a nearly constant factor. The shortness of arm enables a much lighter construction. We have a very great driving power, and virtually set friction at low velocities over against resistance from eddies at high velocities. It may be of some interest to transcribe the record with this anemometer and *B* for 48 hours. In the first set the two instruments were about 20 feet above the roof, and in the second set they were 25 feet high. No attention has been given to the direction of the wind, and the figures are given just as counted from the sheet without checking. The number of turns for each anemometer may be found by multiplying each figure under the anemometer by 500.

COMPARISON OF HOURLY VELOCITIES IN THE WIND OF ANEMOMETERS *B* AND *E*.

	Feb. 12-13.			Feb. 19-20.		
	E	*B*	Factor.	*E*	*B*	Factor.
12-13	13.4	11 2	2.73	15.6	13.8	2.85
13-14	15.2	12.7	2 72	20.2	18.0	2 83
14-15	15.9	13 3	2.71	19.2	16.6	2.76
15-16	12.3	10.0	2.67	18 6	16.1	2.77
16-17	10.4	8 5	2.73	17.0	14.3	2.71
17-18	7.5	6.0	2.80	17.9	15 5	2.78
18-19	6.3	4.8	2.72	12.5	10.6	2.78
19-20	5.7	4.5	2.88	9.6	7.9	2.80
20-21	4 8	3 6	2.84	15.0	13 2	2.85
21-22	8 5	6 7	2.70	19 0	17.5	2 93
22-23	11.4	8.9	2 61	21.8	20.2	2 92
23-24	9.6	7.7	2.74	19.0	17.7	2.96
0-1	13 2	11.2	2.77	10.4	8 8	2 84
1-2	13.8	11 8	2.78	7 3	5.3	2.58
2-3	11.4	10.0	2.88	5.1	3 9	2 84
3-4	10.0	8 2	2.78	11 5	9 7	2.79
4-5	11.6	9 5	2.71	7.9	6 3	2 78
5-6	13.6	11 0	2.65	8.0	6.9	2.97
6-7	11.4	9 3	2 72	10 2	8 9	2.92
7-8	10.8	9.0	2 78	9 0	7.9	2.98
8-9	13 4	11.7	2 85	10.8	9 6	2.94
9-10	15.8	13.3	2.72	12.0	10.3	2 82
10-11	20.0	17.2	2.74	14.6	12.7	2.82
11-12	20.9	17.8	2.71	14.6	13.2	2.93

Anemometers *A*, *B* and *C* were quite similar to those used by Stow in his free wind experiments, taking the Kew as his standard. It would seem possible, with these roof comparisons at

Washington and Stow's field comparisons, to obtain approximately the value of the Kew, which has never been done, especially at low velocities.

KEW FACTOR.

W.	*A*	*B*	*C*	Mean.	Whipple.	St. Petersburg.
5	3.09	3.17	2.83	3.00		3.43
10	2.33	2.49	2.59	2.47	2.26	2.82
15	2.22	2.34	2.40	2.32	2.16	2.67
20	2.06	2.20	2.24	2.17	2.25	2.59
25	2.03	2.17	2.09	2.10	2.12	2.55

These figures from *A*, *B* and *C* are surprisingly accordant. The apparent discrepancy in the case of *C* at low velocities is due to great irregularities in Stow's comparisons with the similar anemometer. The open air experiments in England, already described, are given in the 6th column. It will be seen that they agree very well indeed at velocities above 15 miles per hour. The last column gives the best of Dohrandt's results as embodied in the formula $W = 1.50 + 2.4\ v$. The discrepancies between these results and the free wind results are very great, and it will be seen that no reasonable modification of the latter can remove these differences.

In conclusion it may be said that while we have not arrived at an absolute value of the factor of a single anemometer at high velocities, yet the error is practically nothing in light winds, and is within five per cent. for high winds. It seems entirely possible to construct an anemometer with arms and cups so proportioned as to give a constant factor at all velocities.

February 15, 1889.

TORNADOES IN GEORGIA.

STATE TORNADO CHARTS.—GEORGIA.*

By LIEUT. JNO. P. FINLEY, Signal Service, U. S. A.

TABLE I.—*Tornadoes in Georgia.*

Period of observation, 94 years, 1795–1888.
Total number of storms, 141.
Year of greatest frequency, 1884,—38 storms.
Month of greatest frequency, March,—34 storms.
Day of greatest frequency, February 19th,—22 storms.
Hour of greatest frequency, 2:30 to 3:30 P. M.
Months without storms, August.
Prevailing direction of storm movement, N. E.
Region of maximum storm frequency, central portion.

*For the sake of completeness there will be included in this series the States already published independently, and reviewed in this volume of the JOURNAL, page 374.

TABLE II.—*A Chronological Table, showing the location, date, and time of occurrence and general character of formation and movement of Tornadoes in the State of Georgia for a period of 94 years, from 1795 to 1888.*

County.	Month and Day.	Year.	Time.	Direction.	Form of Cloud.	Width of Path in Feet.
Richmond	.....	1795	.....	.....	.....	.....
Burke	April 4.	1804	Afternoon.	.....	Funnel.	.....
.....	February —.	1805	1 p. m	.....	.....	2,640.
Jones	.....	1818	.....	NE.	.....	.....
Newton, Morgan and Oconee	.....	1824	.....	N 70° E.	.....	1,200.
McIntosh	October 5.	1824	.....	.....	.....	.....
Habersham	April —.	1830	.....	.....	.....	.....
White	April 27.	1832	4 p. m.	.....	.....	900
Bibb	May 14.	1835	Afternoon.	.....	.....	.....
Walker	.....	1836	.....	ESE	.....	.....
Forsyth	February 3.	1842	3:30 p. m	.....	Barrel shaped	300.
Newton and Oconee	.....	1854	.....	N 70° E.	.....	.....
Gwinnett	November —.	1864	.....	.....	.....	.....
Newton and Morgan	January 24.	1866	6 p m.	N 70° E.	.....	300.
Monroe	June 6. ?	1866	11 a m.	NE.	.....	.....
Jones	April 20.	1870	.....	.....	.....	.....
Monroe	April 20.	1871	5:30 a m.	NE.	.....	.....
Walker	Sept. —.	1872	Night.	E 10° S.	.....	1,320 to 5,280
Bibb	November —.	1873	.....	E.	.....	600 to 900.
Pike	.....	1874	.....	NNE.	.....	.....
Jefferson	March 15.	1875	.....	NE.	Funnel.	300.
Richmond	March 20.	1875	11:30 a. m.	ENE.	Funnel.	.....
Jones	March 20.	1875	10 p m.	.....	.....	1,320.
Harris	March 20.	1875	11 a. m.	NE.	.....	1,000.
Columbia	March 20.	1875	1 p. m.	E 2° N.	.....	2,400.
Richmond	March 20.	1875	4:30 p. m.	.....	.....	.....
Screven	March 20.	1875	8 p. m.	NE.	Funnel.	500 to 800
Monroe	March 20.	1875	4 p. m.	ENE.	Funnel.	150 to 5,280.
Putnam	March 20.	1875	4 p m.	.....	.....	.....
Glascock and Richmond	March 21.	1875	12:15 a. m.	N 70° E.	.....	750 to 1,500.
Harris	April 1.	1875	2 a. m.	.....	.....	.....
Harris	April 10.	1875	.....	NE.	Funnel.	300 to 600.
Troup	April 10.	1875	Afternoon.	NE.	Funnel.	375 to 1,200.
Harris	May 1.	1875	2 p. m.	NE.	.....	.....
Newton and Walton	May 1	1875	4 p. m.	N 70° E.	.....	1,200.
Forsyth	December —.	1875	.....	E 20° N.	.....	.....
Hall	January 9.	1876	.....	.....	.....	.....

TABLE II.—*Continued.*

County.	Month and Day.	Year.	Time.	Direction.	Form of Cloud.	Width of Path in Feet.
Richmond	March —.	1876	4:30 p. m.			
Forsyth and other counties	December 12.	1876	11:30 p. m.	NE.		450 to 490.
Thomas	March 8	1877	Afternoon.	NE.		
Richmond	February 8.	1878	1 a m	NE.		800 to 1,000.
Brooks	March 28.	1878	Afternoon.	NE.	Funnel.	300 to 600.
Floyd	April 4.	1878	Afternoon.	NE.	Funnel.	800 to 1,200.
Thomas	September 11.	1878	Afternoon.			
Pulaski	July 13.	1879				
Burke	October 10	1879	Afternoon.			
Whitfield	April 3	1880	3 p. m.	NE.	Funnel.	2,500 to 3,000.
Habersham	April 3	1880	Night	NE.	Funnel.	3,000 to 4,000.
Elbert	April 3.	1880	Afternoon.	NE	Basket.	
Washington	April 4.	1880	Afternoon.	NE.	Funnel.	1,500 to 3,000.
Spalding	April 20.	1880	7:20 p m.	NE.	Funnel.	150 to 300.
Whitfield	April 25.	1880	Sundown.	NE.		1,000 to 3,000.
Gilmer and Connesauga	April 25.	1880	8 p m	E 25° S.	Funnel.	
Walker	July 3.	1880	After noon.	NE.		
Catoosa	July 3	1880	Afternoon.			
Laurens	May 14.	1881	Evening.	SE.	Funnel.	200 to 500.
Fulton	July 12.	1881	5 p m.	ESE.		
Sumter	July 18.	1881	Afternoon.		Funnel.	
Oglethorpe	September 15.	1881				
Burke	March 27.	1882				
Lee	March 27.	1882	11:30 p. m.	E 10° N.	Funnel.	2,640.
Bibb and Washington	March 27.	1882	11 a. m.	ENE.		3,000.
Bullock	March 28.	1882	1 a. m.	E.		1,200.
Sumter	April 9.	1883	4 a. m.	NE.		
Meriwether	April 14.	1883	2 a m	NE.		900 to 1,500.
Sumter	April 22.	1883	Between 3 and 4 p. m.	NE.		
Sumter	April 22.	1883	4:30 a m.	SW. ?		1,350.
Oglethorpe	April 22.	1883	7 p. m.	E.	Funnel.	300.
Emanuel	April 23.	1883	About 6 p. m.			
Sumter and Dodge	April 23.	1883	3:30 a. m.	NE.	Funnel.	900 to 5,280.
Dougherty	April 23.	1883				1,320.
Wilkes	April 29.	1883	3 a. m		Funnel.	2,400.
Floyd	May 20.	1883				
Elbert	June 24	1883	4:30 p. m.	E.	Funnel.	300.
Wilkes	February 19	1884	4:30 p. m.	N.		2,640.

TABLE II.—*Continued.*

County.	Month and Day.	Year.	Time.	Direction.	Form of Cloud.	Width of Path in Feet.
Washington	February 19.	1884	6 p m.	NE.		
Taliaferro	"	1884	5 p m.	NE.		
Talbot	"	1884	2 p. m.	NE.	Funnel.	300.
Richmond	"	1884	6:45 p m.	NE.	Funnel.	600 to 2,640.
Putnam	"	1884	Afternoon.	NE.		
Muscogee	"	1884	12:10 p. m.	NE.		
Monroe, Jones and Putnam	"	1884	4 p m.	NE.	Funnel.	300 to 600.
McDuffie and Columbia	"	1884	5:45 p. m.	N 55° E.	Cone	450 to 1,200.
Jasper and Putnam	"	1884	4 p m.	NE.	Funnel.	1,200.
Jasper	"	1884	3:30 p. m.	NE	Funnel.	500
Haralson, Cherokee and Pickens	"	1884	1:30 p m.	NE.	Funnel.	1,320 to 2,640.
Hancock	"	1884	5 p. m.	NE.	Funnel.	300.
Gwinnett, Jackson and Madison	"	1884	3 p m	E 30° N.	Funnel.	300 to 700
Forsyth	"	1884	1:20 p. m.	NE.	Hour glass.	150
Coweta	"	1884	4:30 p. m.	NE.	Funnel.	2,640
Coweta	"	1884	2:04 p. m.	E 30° S.	Funnel.	2,640 to 5,280.
Coweta	"	1884	2:30 p. m.	NNE.		
Washington	"	1884	6 p m.	E 30° N.	Funnel.	300 to 600.
Burke	"	1884	7 p m.	NE.		
Banks	"	1884	3:30 p. m.	NE.		600 to 1,200
Floyd	"	1884	2 p. m.	NE.	Balloon.	1,320 to 3,960
Troup	March 25.	1884	5:30 p m.	NE.	Funnel.	
Carroll	"	1884	5 p. m.	E.	Funnel.	300.
Floyd	"	1884	2 p m.	NE.	Funnel.	300.
Milton, Forsyth and Hall	"	1884	1:15 p m.	NE.	Funnel.	300 to 400.
Oglethorpe	"	1884	12:15 p. m.		Funnel.	
Forsyth	"	1884	1 p m.	NE.	Funnel.	
Cherokee	March 26.	1884	p m.	NE.	Funnel.	
Cobb and Hall	April 1.	1884	1 p. m.	E 30° N.		200
Walker and Pickens	April 1	1884	8:30 p. m.	E 10° S.	Funnel.	1,320 to 5,280.
Troup and Pike	April 14.	1884	1:30 p. m.	NE.		900 to 1,500
Gordon	April 14	1884	7:30 p m			
Franklin	May 3	1884	6 p. m.			
Lumpkin	June 2.	1884	9:30 a m. ?		Funnel.	2,640.
Bibb	December 22	1884	11 a m.			
Oglethorpe	December 22.	1884	2 p m.			225
Berrien	December 24	1884	Evening.		Funnel.	
Jones and Baldwin	January 11.	1885	Midnight.	E 25° N.		600 to 900.

TABLE II.—*Concluded.*

County.	Month and Day.	Year.	Time.	Direction.	Form of Cloud.	Width of Path in Feet.
Burke	January 12.	1885	3 a. m.	E	.....	3 000.
Mc'uffie	February 9.	1885	6 p. m.	E 18° N.	Cone.	900 to 1,200.
Warren	February 9	1885	6 p. m.	NE.	.....	.....
Baker and Mitchell	March 27.	1885	5:50 p. m.	E 5° S	Funnel	300 to 900
Haralson	May 9.	1885	9 p. m.	NE.	Whirlwind.	300 to 1 200.
Chatham	March 20.	1886	Afternoon.	NE.	Funnel.	.....
Ware	March 20.	1886	4 p m.	E.	Funnel.	375.
Bullochs.	March 29.	1886	Afternoon.	Easterly	Funnel.	.....
Harris	"	1886	Afternoon.	NE	.....	.....
Troup	"	1886	1:15 p. m	NNE.	Funnel.	150.
Ca pbell	"	1886	3 p m.	NE.	.....	.....
Baldwin	May 18.	1886	6:30 p. m.	NE.	Funnel.	.....
Chatham	July 4.	1886	2:05 p. m.	Easterly	Funnel.	.....
Gordon	July 10	1886	Afternoon.	.....	.....	.....
Clay and Randolph	February 18	1887	Afternoon.	NE.	Funnel.	1,320 to 2,640.
Putnam	February 26.	1887	4:15 p. m.	NE.	Funnel.	150 to 230.
Butts	February 26	1887	4 p m.	NE.	Funnel.	600 to 1 320.
Jefferson	March 31.	1887	6 p m.	NE.	Funnel.	600 to 900.
Cobb and Cherokee	April 3.	1887	8:30 p m	E.	.....	Na row.
Polk and Floyd	April 22.	1887	8 p. m	E.	.....	300
Carroll and Campbell	June 1.	1887	7:10 p. m.	E	Funnel.	300 to 450.
Coweta	June 1.	1887	7 p m	NE.	Funnel.	100 to 900.
Oconee	July 24.	1887	6 p m.	NE.	Funnel.	Narrow.
Montgomery	March 21.	1888	4 a m.	Easterly.	Funnel.	1 320
Gordon	March 20.	1888	11 p m.	NE.	Funnel.	300 to 600.
Cobb	March 20.	1888	10:30 p. m.	NE.	.....	Narrow.
Muscogee.	October 2.	1888	4 p m	Easterly.	Funnel	Narrow.

TABLE III.—*Relative frequency of Tornadoes by months and days, for Georgia.*

The index figures to the right and above the dates show how many times tornadoes occurred on that day of the month.

Month.	Day of Month.	No. of Days.	Total No. of Tornadoes per month.
January	9, 11, 12, and 24	4	4
February	3, 8, (9)^2, 18, (19)^{22}, (26)^2, and (—)	7	30
March	8, 15, (20)^{12}, (21)^2, 22, (25)^6, 26, (27)^4, (28)^2, (29)^4, and 31	11	34
April	(1)^3, (3)^4, (4)^3, 9, (10)^2, (14)^3, (20)^3, (22)^3, (23)^3, (25)^2, 27, (29)^2, and (—)	13	32
May	(1)^2, 3, 9, (14)^2, 18 and 20	6	8
June	(1)^2, 2, 6, 12, and 24	5	6
July	(3)^2, 4, 10, 12, 13, 18, and 24	7	8
September	11, 15, and (—)	3	3
October	2, 5, and 10	3	3
November	(—)^2	1	2
December	12, (22)^2, 24, and (—)	4	5
(—) Blank	(—)^6	1	6
Total		65	141

NOTE.—The blank (—) signifies date missing.

TORNADOES IN WISCONSIN.*

* See tables in the preceding number of this JOURNAL, pages 473–477.

CORRESPONDENCE.

THE METEOR OF FEBRUARY 7TH.

To the Editors:—An exceedingly brilliant meteor swept across the southern sky of this city about sunset on the evening of February 7th, at an elevation not far from 30 degrees. It was observed at various points in New Jersey and Connecticut. The sound of the final explosion was reported to have been heard at Burlington, New Jersey, over which it would seem to have been nearly central. Its brilliancy in the heavens still illumined by the sun, suggested a startling aspect had the hour been later. As described by an observer at Lake Hopatcong, N. J., it resembled the head-light of a locomotive, and was followed by a long funnel-shaped trail of greenish-blue fire, which suddenly changed to an intense red, accompanied by myriads of sparks, and then followed the explosion. As observed by the writer at Newark, N. J., it had the deliberate tremulous motion of a rocket, indicating that it was well within the limits of the atmosphere.

A subsequent sextant measurement of the arcs by the writer, from memory only, gave a velocity of not far from 8 to 10 miles a second at an altitude of from 20 to 25 miles. Its apparent course was nearly in the same plane with the earth's orbit, crossing the latter nearly in a western direction horizontally.

The following conclusions, though of course hypothetical, were suggested. Since the density of air at that elevation is only about one-hundredth of that at the earth's surface, and that of the latter equivalent to a uniform atmosphere five miles high, the air displaced if its passage had been vertical would have been equivalent to a horizontal range at the earth's surface of about 260 feet, and with a horizontal passage equivalent to a range some 16 times greater. These rough estimates would indicate a meteor of large size and a large loss of initial velocity. A loss of only 60 per cent. would give an initial westerly component of from 20 to 25 miles, in addition to a component of 20 miles in the direction of the earth's orbit. Aside from the

velocity due to the earth's attraction, and which must have been within 7 miles, a resultant velocity of only about 25 miles would be needed for an elliptical orbit with a major diameter more than double that of the earth, while a velocity of less than 30 miles would have been needed for a hyperbola. Hence the inference seems strong that the meteor was approaching its perihelion along an orbit of great eccentricity, similar in character to those of the August and November meteors.

WALTER S. NICHOLS,
Associate Editor of the Ins. Monitor.

NEW YORK, February 14, 1889.

THE MIGRATORY FLIGHT OF WILD GEESE.

To the Editors:—All are familiar with the appearance of the migrating wild geese, that, moving northward in early spring and returning south about mid-autumn, appear to many observers the signal of decisive seasonal changes. Along with other migrating birds, their flight is often coincident with, or only a little in advance of a general and far-reaching atmospheric movement in the direction of their line of passage.

A singular feature in the semi-annual flight of geese, is the way in which they arrange themselves about the leader — forming two sides of a triangle, with the patriarch of the flock at the apex.

I have never seen any explanation of this peculiar arrangement of the flock in its migrations, and, so far as I know, it is peculiar to this species of bird.

Some years ago, however, I had the opportunity of observing daily near at hand, the movements of water-fowl on the waters of the Amazon river, where geese and ducks, both wild and domestic, are seen in great abundance and almost infinite variety. I there noted for the first time the behavior of a brood of goslings, apparently just out of the shell, as they followed the mother to a pond, and, as yet hardly able to walk, fairly tumbled into the water in her wake. Once in the water, however, they moved with more ease and precision, and I saw them arrange themselves in triangular lines, as geese do in their migrations, — following the mother.

This movement on the part of the goslings appeared to me to be automatic, i. e., prompted by a mechanical cause; for as the mother swam out, causing a widening ripple on each side, the young brood, seemingly without effort of their own, floated on the movement thus initiated, naturally stopping and arranging themselves along the line of the ebb of the ripple.

As my work about the mill placed me in sight of the pond for many months, I saw frequently what I have just described, and could hardly help surmising that the arrangement of the geese in flight was simply a revival of the instinctive impression first called out by experience in the water, as I have described.

I have never had an opportunity of verifying these observations since, but drop you this note, thinking that, if there is any novelty about it, some person better situated may continue the investigation.

LUM WOODRUFF.

GALLINAS, ATASCOSA COUNTY, TEXAS, December, 1888.

HEAVY RAINFALL AND ITS CONSEQUENCES.

To the Editors:—In the month of June, in the year of 1885, there occurred at this place a heavy rain-storm accompanied by terrific thunder and lightning. The storm lasted perhaps an hour, during which time there fell nearly three inches of water. Immediately thereafter, a large number of fish, probably of the sucker variety, were seen standing upright in the water of a mill pond near my house. Their heads were downward and their tails projected above the water sufficiently far to expose the dorsal fin. They remained in this position for about ten minutes, when they disappeared. They were of such size that they would probably weigh from two to four pounds each.

S. ALEXANDER.

BIRMINGHAM, MICH., December 10, 1888.

CURRENT NOTES.

AIR PRESSURE IN EUROPE.*—This volume is "Band II, Heft 2" of the "Geographische Abhandlungen," published by Professor Dr. Albrecht Penck, of Vienna.

The 220 pages of this work are divided into the following sections:

Introduction.

I. chapter. On the methods for obtaining comparable mean air pressures, and for drawing correct isobars.

II. chapter. The monthly and annual isobars of central and southern Europe.

III. chapter. Annual periods in the air pressure relations of Europe.

IV. chapter. Connection between the air pressure anomalies of Europe and the temperature anomalies in Central Europe.

V. chapter. The mean and absolute variability of the monthly and annual means of air pressure.

VI. chapter. The probable error of the 30 year mean air pressure, and the effects of this.

VII. The variability of the differences of the mean air pressures of two places.

VIII. Reduction to the normal period of 1851–1880.

IX. Reduction of the mean air pressures to the same level.

X. Many year period of the air pressure.

Appendix: Special references for the derivation of the 30 year mean air pressure for central and south Europe. (Showing the barometer corrections, source, etc.). Air pressure means for the period, 1851–1880. Monthly and annual means of air pressure for each year for some normal stations; with five year periods also.

The three plates at the end of the volume contain the isobars for each month and the year reduced to sea-level, and for Jan-

*Die Vertheilung des Luftdruckes über Mittel-und Süd-Europa dargestellt auf Grundlage der 30 jährigen Monats-und Jahres-Mittel, 1851–80. nebst allgemeinen Untersuchungen über die Veränderlichkeit der Luftdruck-Mittel-und-Differenzen sowie deren mehrjährige Perioden, von J. Hann. Wien., 1887.

uary, May, July, October, and the year reduced to 500 meters elevation.

Nearly all of the barometric means are reduced to the standard of the Vienna Observatory (Barometer Pistor 279), and no small portion of Professor Hann's labor in carrying out this work has been the collecting and applying the absolute corrections of the different station barometers whose readings are employed in the work. The information collected in this connection will always be of use to any one making a comparison of barometer observations made in different parts of Europe. There is somewhat of an uncertainty regarding the Vienna standard barometer, as to its having undergone some change in its removal, and remounting, in 1872, but the adopted standard refers to the barometer *after* 1872. In regard to this supposed change in Pistor 279, Professor Hann finds that a comparison of 30 year means of observations at several stations (Vienna, Hermannstadt, Munich, Warchau, Laibach), shows a lowering of Pistor 279 by 0.23 mm., while Dr. Liznar's report shows a raising by 0.27 mm. A barometer at Kremsmünster, that had been in use many years, seemed to indicate that the barometer Pistor 279 had not undergone any change.* Dr. Hann remarks that these discrepancies have not yet been cleared up.

Particular attention has been given to the reduction of the observation, to the same level (sea level), and great accuracy has been attained as is shown by the agreement of neighboring stations having different altitudes. The great number of careful "spirit level" surveys made by the different governments have been used to the full extent of their accuracy. There are so many important parts to this memoir that only a few can be mentioned here. On page 52 is an interesting diagram showing the annual period of the air pressure in various portions of

*I have examined into this question as carefully as I can, and am of the opinion that the indication of the Kremsmünster barometer is not far from right, and that the barometer Pistor 279 now has nearly the same reading as before 1872, although it may have been raised by half a tenth of a millimeter. This view is based upon the supposition that the standard barometers at Greenwich, Hamburg, Stockholm and Upsala have remained unchanged. However, this is a difficult point to decide on account of the different results obtained by various intercomparisons of European Normal Barometers since 1880. See the reports of Chistoni, Waldo and Sundell. F. WALDO.

Europe. The curves are quite irregular, showing the phases from continental to oceanic climates. The great difference in the mean annual oscillation of the barometer on the Coast and Inland (amounting at Wallachia to four times what it is on the coast of the North Sea), is clearly shown.

The relation between the temperature and air pressure deviations for the seasons is carefully investigated by Professor Hann, and some of his work led to definite results, while some merely showed that no connection existed between the phenomena compared. For instance, "In all cases of very warm winter months in Central Europe, the air pressure in the N. W. over the Atlantic Ocean was too low; if Central Europe alone is considered, very cold winters occur just as frequently by high as by low pressure.

The following table shows approximately the dependence on the latitude, of the average variability of the monthly and annual air pressures:

Latitude.....	60°	56°	52°	48°	46°	43°	38°	32°	20°
	mm.								
Mean Mo.....	3.06	2.92	2.58	2 34	1.95	1.80	1.48	1.00	0.40
Annual.....	1.14	0.96	0.78	0.72	0.59	0.56	0 48	0.36	....

In getting the probable error of the many years mean, the formula of Fechner is used. If n = number of years of observation (or the number of observations in general) then,

$$\text{Probable error} = \frac{1.1955}{\sqrt{2n-1}} \times \text{average deviation.}$$

The following values of the factor by which the average deviation is to be multiplied, may be of service to others,

$$\left\{\frac{1.1955}{\sqrt{2n-1}}\right\}:$$

n	0	1	2	3	4	5	6	7	8	9
10	0.274	0.261	0.249	0.239	0.230	0.222	0.215	0.208	0.202	0.196
20	.191	.187	.182	.178	.174	.171	.167	.164	.161	.158
30	.156	.153	.151	.148	.146	.144	.142	.140	.138	.136
40	.134	.133	.131	.130	.128	.127	.125	.124	.123	.121
50	.120	.119	.118	.117	.116	.114	.113	.112	.111	.110

The following little table gives a general idea of the *probable errors* for *grouped* barometer observations:

Groups.	Probable error of the 30 years' mean air pressure in mm.				Number of years necessary for a probable error of ± 0.1 mm.			
	Month of		Mean Month	Year.	Month of		Mean Month.	Year.
	Max	Min.			Max.	Min.		
West-Greenland	0.68	0.30	0.45	.....	1393	271	606	.....
North Atlantic Ocean	0.78	0.37	0.55	0.19	1840	412	802	112
North Sea Group	0.71	0.27	0.45	0.15	1540	218	607	64
Baltic Sea Group	0.64	0.23	0.43	0.15	1240	159	542	68
North Central Europe	0 58	0.19	0.35	0.11	1022	108	374	35
South Central Europe	0.57	0.15	0.32	0.10	968	67	303	29
S.E. Europe	0.39	0.13	0.23	0.07	461	47	159	16
S.W. Europe	0.46	0.11	0.26	0.10	646	37	210	30
West Mediterranean Sea	0.48	0.12	0.26	0.08	690	42	207	20
Tropics	0.08	0.05	0.06	0.04	21	9	13	5

Professor Hann's remarks on the formula for reduction to sea level, and the simplification of this formula for stations of low elevation, are of much interest to those who find it necessary to make such reductions, but we cannot enter into the subject here.

In regard to the "*many year*" period of the mean annual air pressures, no definite law was established, although the positive and negative deviations lie in groups of unequal distribution. Still the author makes the statement at the close of the chapter that the mean air pressure has not only considerable "*many year*" oscillations in relation to its absolute reading, but also in relation to its annual variation.

We find also given in the main tables, the mean pressure for each month and year for 205 places, as *observed*, and then as *reduced to sea level*, for the period 1851–1880; for 65 places the reduction is also made to the elevation of 500 meters above sea level. There is also given, for 39 Normal Stations, the air pressure for each month and year for long periods, and also in groups of 5 years.

In glancing over the charts we find at sea level, in *January* a Low over the Mediterranean Sea (762.0), Highs over Spain (766.0), Austrian Alps (766.5), and Northern Turkey and Bulgaria (766.5), with the 761.5 Isobar skirting the coast of Belgium, Holland and Germany.

In *April* we find Highs in Algeria (762.5), Eastern Spain (762.0), Central Rhine Region (761.5), Southern Russia (761.5), and *Lows* in Western Mediter. Sea (759.5), Eastern Mediter. Sea (760.0), Eastern and Northern coast of the Adriatic (760.0). In Northern Germany the pressure is between 760.5 and 761.0. Throughout the whole of Central Europe the gradients are slight.

In *July* we find *Lows* in Spain (762.0), extreme Eastern Medit. Sea (757.0), Northern Italy (760.5). In S.W. Russia we find the 759.0 Isobar and in S.E. England the 761.5 Isobar. In the Bay of Biscay there is a *High* of 764.0.

In *October* we find *Lows* in S.E. England (759.0), Western Medit. Sea (761.0), Eastern Medit. Sea (761.0). *Highs* are in Algeria (763.0), Spain (762.5), S.E. Alps (763.5), Southern Russia, Crimea (765.0).

For the *year* there are *Highs* in Spain (763.5), with 763.0 in N.W. Africa, S.W. Russia and Eastern Hungary (762.5). *Lows* are in the Central and Eastern Medit. Sea and Adriatic Sea (761.0), and across Northern Europe where the Isobars run nearly *E.* and *W.* In the extreme north of Scotland and Norway we find the 758.5 Isobar. F. Waldo.

The San Felipe Sink.—Dr. Walter Lindley, in the *Medical Record*, gives an interesting account of this tract, which lies below sea-level. Dr. Lindley discusses it from the therapeutic point of view, claiming that in it the patient can get the curative effect of compressed air. As to its physical peculiarities, fauna, and flora, Dr. Lindley says:

"Dr. J. B. Widney, of Los Angeles, while surgeon in the United States Army, crossed this region with troops twenty-one years ago. He then noticed surrounding this territory a well-defined line along the mountain-sides, always at the same level. Above that line the rocks are sharp and jagged, showing that for ages the water had stood at that level. He says: 'I found it to be the old beach of a sea.' I find nothing else noted of this country until the surveying party of the Southern Pacific Railroad, in running the line from Los Angeles to Yuma, found that sea-level was at the point where Dr. Widney had noted the ancient beach. They then gradually descended to the south until they reached a depression of two hundred and sixty-eight feet below sea-level, at a point near Salton.

"This basin is about one hundred and thirty miles in length by thirty miles in average width. The deepest point is about three hundred and sixty feet below sea-level. Along the northern margin of this basin, right up against the mountains, are great numbers of date-palms. These tropical trees are indigenous to this valley, and many of them reach a height of eighty feet. When ripe, a single bunch of the fruit weighs one hundred pounds. It has a taste very similar to the date-palm of commerce. The tree has large fan-leaves, and is the same as can be seen in almost every park and yard in the towns of Southern California. The passenger on the Southern Pacific Railroad, by glancing out of the north side of the car at Indio, can see these giant sentinels keeping silent vigil over the plains beneath them.

"At Salton, on the Southern Pacific Railroad, the surface of the earth for nearly ten miles square is covered with a crust of salt from four inches to a foot thick. I stopped there in midsummer and went out on this great white field about noon. The mercury indicated 105° F. in the house, but out in the sunshine, with the dazzing reflection from the glistening surface that extended for miles on each side, the temperature was probably 130° F. The workmen out in this peculiar harvest-field were as cheerful as any set of men I ever saw, and there was far less exhibition of suffering from heat than is to be seen, ordinarily, in July, in the wheat fields of the Mississippi Valley. The low relative humidity explains the total absence of sunstroke here. The atmosphere in this region, adulterated by the chlorine gases emanating from the salt-beds, must be nearly aseptic. There are extensive mills here for grinding the salt. It is not put through any system of purification, but, after grinding, proves to be excellent for table use. Several hundred tons are thus prepared every month, and shipped away.

"A few miles east of here are the famous mud volcanoes, which are equal in wonder to the geysers of this State. Owing to the treacherous character of the ground around them they have never been thoroughly examined. Professor Hanks, the State mineralogist, undertook it, but breaking through the crust he was so severely burned that he was compelled to abandon his investigations. Here is an extensive, almost unexplored field for some adventurous scientist.

"Indio is the place to stop and make headquarters for tours through this interesting country. It is the principal station in the valley, and is near the northern rim of the basin, being only twenty feet below sea-level. The sandy plains around Indio were formerly considered a hopeless barren waste, but the advent of the railroad has made great changes. Good water is supplied by surface wells; but in order to have water for irrigation, artesian wells have been bored. There is one two and three-fourth miles east of Indio that is now flowing one thousand gallons per

hour. This flowing water was reached at a depth of only one hundred and fifteen feet, after boring through layers of sand, clay, sand, tough blue clay, clay, coarse gravel, clay, and sand. Oranges and various other kinds of fruit are being grown here, and melons, tomatoes and berries ripen several weeks earlier than at Los Angeles and other places near the coast. There are in this vicinity about forty thousand acres of excellent land. The visitor here, on witnessing the water flowing from the artesian wells, the grass growing, the melons ripening, and the peach-trees blooming, can fitly say with Isaiah: 'The Lord shall comfort all the waste places. He will make the desert like the garden, and the desert shall rejoice, and bloom as the rose. For in the wilderness shall waters break out, and streams in the desert. And the parched ground shall become a pool, and the thirsty land springs of water.'

"In this valley live about four hundred of the Cohuilla Indians. This is an interesting tribe. Dr. Stephen Bowers, in a paper read before the Ventura County Society of Natural History, March 5, 1888, said that he believed them to be of Aztec origin. They are sun and fire worshipers, and believe in the transmigration of souls, and that their departed friends sometimes enter into coyotes, and thus linger about their former habitation. They practice cremation. Their principal article of food is the mesquit bean, which they triturate in mortars of wood or stone, after which the meal is sifted and the coarser portion is used as food for their horses and cattle, and the finer is made into cakes for family use.

"The agave, or century-plant, which is indigenous here, is also much used for food. The roots, roasted, taste like stewed turnips, while the stem, roasted, is said to taste like baked sweet-potatoes. From this plant they also make the Mexican beverage, *pulque*, which has about the same alcoholic strength as beer. The ethnologist can, by gaining their confidence, get much interesting information from these very peaceable Indians.

"I found at Salton and Indio asthmatics, rheumatics, and consumptives, all of whom reported wonderful recoveries. Some of these stories I accepted *cum grano salis*, which quotation is, by the way, especially applicable to the salt-fields. These asthmatics and consumptives claim that the farther they get below sea-level and the dryer the atmosphere, the easier they breathe. The rheumatics claim that the heat and dryness improves the circulation, and thus relieves them."

Among other places below sea-level, Lindley notes the sink of the Amorgosa (Arroyo del Muerto), in eastern California, two hundred and twenty-five feet below sea-level. The Caspian Sea, eighty-five feet below sea-level. Lake Assal, east of Abyssinia, in the Afar country, eight miles long and four miles wide, is

about seven hundred and sixty feet below sea-level. Its shores are covered with a crust of salt about a foot thick. This salt is a source of revenue to the Afars, as they carry it by caravans to Abyssinia, where they find a ready market. There are several other depressions about six hundred feet below sea-level in this vicinity. The noted oasis, Siwah, in the Libyan desert, three hundred miles west of Cairo, is one hundred and twenty feet below sea-level. Here are beautiful date-palm groves, and here also the apricot, the olive, the pomegranate and the vine are extensively cultivated. In this same desert is the oasis Araj, two hundred and sixty-six feet below sea-level. There are also numerous other depressions in the desert portion of Algeria and at various points on the Sahara Desert.

THE GREAT STORM OFF THE ATLANTIC COAST, MARCH 11–14, 1888.—The literature of this subject has been enriched by a paper prepared by Mr. Everett Hayden, U. S. Navy, in charge of the division of Marine Meteorology, U. S. Hydrographic Office. It discusses the observations made by vessels off the coast during that disastrous storm, and thus supplements the papers already published which discuss those made on land. The path of the cyclone was wholly in the ocean, after it entered the Atlantic as a mild storm on the Carolina coast; its great development was wholly in the ocean, and therefore this paper is a supplement to those already published in time merely. In importance it outranks the earlier contributions, and it may be said at the outset that the treatment of the observations and the discussion of the results are proportionate to the importance of the subject.

The paper has appeared in two forms—in the *National Geographic Magazine* and as Nautical Monograph No. 5. The *Magazine* is published by the National Geographic Society, an incorporated society organized at Washington in January, 1888, before which a number of valuable papers have already been read. The two forms of the paper are nearly alike; in the Nautical Monograph there are fuller citations from the reports of mariners, and several appendices are given which do not appear

in the *Magazine*, as they were not a part of the paper as read before the society.

The Monograph begins with four charts, carefully prepared and finely executed in color, showing the meteorological conditions at noon, March 11, 12, 13 and 14. Two other charts show the positions of the trough of low barometric pressure and the tracks of certain vessels, and the fluctuations of pressure. The text follows, and explains in detail the charts, giving the history of the storm, a brief statement of the laws of cyclonic storms, and of the ocean factors such as the Gulf Stream and Labrador current, which cause oftentimes such an increase in intensity of cyclones which enter the ocean from the land. It contains well selected extracts from the reports of vessels, and a chapter upon the use of oil in preventing heavy seas from breaking, as illustrated in this storm. The appendix consists of four tables: the first contains miscellaneous data, such as records of wind, snow and rain, barometric oscillations, compiled from various sources; the second is a sadly long list of vessels wrecked; the third is made up of detailed reports from vessels, and the fourth gives the observations at Greenwich noon, on successive dates, from which the charts were constructed.

Examining the charts and text, the reader notes at once that deserved prominence is given to the trough feature of the storm. This trough on the first day, the 11th, extended from the Gulf of Mexico northerly into Canada. As it moved easterly the southern end moved with the greater velocity, giving the trough the appearance of having swung around, so that on the 14th it was well nigh perpendicular to its position on the 11th. Several centres formed in this trough. On the 11th there were two, one in Canada, the other less severe in South Carolina. The latter developed great energy after it reached the ocean, and turning northeasterly reached the New England coast and was dissolved, while another center forming in the ocean south of the former continued a northeasterly course in the Atlantic. The daily charts do not make it perfectly clear when the last named cyclone was formed, nor whether it was the second which came up the coast to New England, but the charts of the U. S. Signal

Service, published in the March *Weather Review*, supply the needed information on the latter point, though they throw no light on the former. It is probable, however, that the third centre formed on March 12th as drawn, but it may be doubted whether the data themselves are quite sufficient to give this information and to warrant the enclosing of two elliptical areas rather than one on the chart.

The chief interest of the publication lies in its skillful handling of marine data. The land meteorologist with his fixed stations, does not realize the difficulties of the marine metereologist whose stations are moving, and whose barometers may have considerable changes in their instrumental corrections from time to time. In the tabulation, correction, and discussion of marine reports, the author has shown great care and skill, and much of his work (such as the critical examination of the reports, correspondence with the mariners, and calculation of instrumental corrections), does not appear in the final publication. The result of all this painstaking is apparent in the tables and charts, which are models of their kind.

The paper is written primarily for the benefit of navigators, and is therefore quite full in its quotations from the records of vessels, and in the discussion of the practical subject, the use of oil. It is for the same reason written in an easy popular style, and it is bound in a more durable manner than is usual with such publications. The reviewer has noted nothing deserving adverse criticism, but would suggest that the use of the colloquial "low" and "high" might be advantageously discontinued by several writers on meteorological subjects. A question may be raised whether the statement that areas of high pressure move as a rule more rapidly and with greater momentum than low areas, has been accepted as a clearly established fact. Without having actually examined the statistics, the reviewer would doubt this, so far as the eastern United States is concerned.

The monograph is numbered 5, and will compare formably with its predecessors. The first three are Maury's papers on the Winds at Sea and two on the Barometer at Sea, all written

before the civil war, while the fourth is a brief discussion of two cyclones which were felt in the North Atlantic, in August, 1883. The monograph now issued shows the advance which has been made in the methods of carrying on such investigations, especially in the matter of collecting simultaneous observations even at sea, and preparing synchronous charts. W. U.

THE METEOROLOGICAL RESULTS OF THE TOTAL SOLAR ECLIPSE. —A very complete series of meteorological observations was made at Willows, California, during the eclipse of January 1, 1889, by Professor Winslow Upton, of Brown University, Providence, R. I., and A. Lawrence Rotch, of the Blue Hill Meteorological Observatory, near Boston. Both these gentlemen had made meteorological observations during the total solar eclipse of August 19, 1887, in Russia, and owing to the nature of the observations they were less affected by the unfavorable weather than were the astronomers. The instrumental equipment of the party for meteorological work in 1889 has probably not been equalled in this or previous eclipses. It consisted of a recording aneroid barometer with large time and pressure scales, a recording wind-vane and anemometer, recording thermometer for air temperatures and recording solar thermometers with black and bright bulbs. There were also the standard instruments for eye readings including thermometers for air and sun temperatures and three aneroid barometers.

The full discussion of the observations will probably be published with the astronomical work of Mr. W. H. Pickering in the *Annals of the Harvard College Observatory* and in abstract in this JOURNAL. The results of the observations may be summarized as follows: The sky was perfectly clear during totality. The fluctuations of the barometer due to the eclipse were small, and possibly were within the limits of errors of observation. The air temperature fell about six degrees below its normal, and the black and bright bulb thermometers *in vacuo* approached to within 1.6° F. of each other, the lowest temperatures in both cases occurring several minutes after totality was over. No dew formed. The wind backed slightly in direction and its

velocity decreased almost to a calm before totality; it veered again and its velocity increased afterwards. Drawings were made with a three-inch telescope and with the naked eye, of the sun's corona, which resembled that of 1878. The darkness during the total phase was less than in 1887, when it was cloudy, and was estimated to equal that of twenty minutes after sunset.

Professor Upton has for some time been interested in the "shadow bands," the long dark bands separated by white spaces which are seen moving rapidly on the ground or sides of buildings, just before and just after the total phase of an eclipse. These were seen by Professor Upton, at Willows, and an attempt was made to photograph them. Professor Upton had previously distributed circulars to persons living along the line of totality, especially at places near the edge of the shadow, requesting information upon the following points: (1) the direction in which the bands lay; (2) the direction in which they moved; (3) the velocity with which they moved; (4) the width of the bands and their distance apart. He has received a number of replies to the circulars, and hopes by discussing the data to throw some light on the curious phenomena of the shadow bands which have not yet been satisfactorily explained.

Through the enterprise of Professor D. P. Todd, who had distributed a cipher code to all the eclipse observers, and the generosity of the Western Union Telegraph Company, in puting at his service a special wire, three thousand miles long, from California to New York, the results of the observations reached New York before the moon's shadow left the earth, thus proving the availability of the telegraph in subsequent eclipses, to call the attention of observers in the east to phenomena previously noted by western observers as worthy of study. The deciphered astronomical and meteorological dispatches were published in full the morning after the eclipse by the *New York Herald.* A. L. R.

Royal Meteorological Society.—The Anniversary Meeting of this society was held on Wednesday evening, January 16th, at the Institution of Civil Engineers, 25 Great George Street, Westminister: Dr. W. Marcet, F. R. S., President, in the chair.

Mr. Maxwell Hall, Mr. G. T. Livesey, M. Inst. C. E., Mr. C. W. Priestlay, B. Sc., Mr. J. Radcliffe, and Rev. J. R. Stratten, were elected Fellows of the Society.

The report of the Council showed that a large amount of work had been done during the past year, and that considerable progress had been made in the investigation of one of the most interesting and hitherto neglected branches of meteorology, viz, thunderstorms. Forty-nine new Fellows were elected last year, the total number on the books now being 525.

After the report had been adopted the President delivered an address on "Fogs," which he illustrated by a number of interesting lantern slides. Fogs and clouds are one and the same thing. A cloud is a fog when entered into, and a fog seen from a distance, suspended in the air, becomes a cloud. After describing the various kinds of fog, e. g., river, sea, Newfoundland, radiation, town, etc. fogs, Dr. Marcet referred to London fogs. Dr. Tyndall has accounted for them by assuming each particle of condensed vapor to be covered by coal-smoke. These fogs usually accompany a high barometer, and are frequently dry in their character. It is a well-known fact that cold air on the tops of hills being heavier than the air below, slides down the slopes, so that the lower parts of hill-sides are actually colder than the plains at some distance from the hills. Now, London, in the Thames valley, is surrounded by hills to the north Highgate, Hampstead and Harrow, in a westerly direction, Putney and Wimbledon; and in a more southerly direction, Clapham, and Sydenham. The air is colder on these hills than in London with its million of inhabitants, its coal fires and factories, hence, it is heavier and will have a great tendency to slide down the hills toward the town and the river. Should the air in town be on the point of saturation, and the cold air from above saturated with vapor, it is obvious that the increased cold from above will produce a precipitation of moisture, and it will come to pass that a fog is produced. If the hill-tops be not only colder than the air below but enveloped in a fog, it stands to reason that the fog below will be all the denser, and especially in the neighbor-

hood of water, such as the river Thames, and the ornamental waters in the parks.

The list of Officers and Council for the ensuing year presents but few changes on that of the year past. The president and secretaries remain the same.

The monthly meeting for February of this Society was held Wednesday, the 20th, at the Institution of Civil Engineers, 25 Great George Street, Westminister: Dr. W. Marcet, F. R. S., President, in the chair.

Mr. H. D. Richmond, F. C. S., and Dr. F. G. Smart, M. A., F. L. S., were elected Fellows of the Society.

The following papers were read:

(1). "Report on the Helm Wind Enquiry": by Mr. W. Marriott, F. R. Met. Soc. The Helm Wind is peculiar to the Cross Fell range of mountains in Cumberland, which runs from north-north-west to south-south-east. This range is high and continuous, and is not cut through by any valley. Cross Fell is 2,900 feet above sea level. From the top of the mountains to the plain on the west there is an abrupt fall of from 1,000 to 1,500 feet in about a mile and a half. At times when the wind is from some easterly point the Helm forms over this district; the chief features of the phenomenon being the following: A heavy bank of cloud rests along the Cross Fell range — at times reaching some distance down the western slopes, and at others hovering just above the summit; while at a distance of two or three miles from the foot of the Fell a slender roll of dark cloud appears in mid-air and parallel with the Helm Cloud; this is the Helm Bar. The space between the Helm Cloud and the Bar is usually quite clear, while to the westward the sky is at times completely covered with cloud. The Bar does not appear to extend further west than about the river Eden. A cold wind rushes down the sides of the Fell and blows violently till it reaches a spot nearly underneath the Helm Bar, when it suddenly ceases. The observations that have been made in the district during the past three or four years show that the Helm Wind is not such a rare occurrence as it was popularly supposed to be, the Bar having been observed on 41 occasions in 1885; 63 in 1886, and 19 in 1887.

The phenomenon takes place usually when the sky to the eastward is covered with cloud.

(2). "An Atmospheric Sketch": by Mr. F. A. Velshow, F. R. Met. Soc.

(3). "The Drought in New South Wales in 1883–4, and Rainfall at Corella, 1879–88": by the Ven. Archdeacon Wynne, F. R. Met. Soc.

THE SNOW LIMIT.*—The subject of the snow limits on mountains is of great interest to all geo-physicists, and the present paper is of much value on account of the completeness with which it deals with this phenomenon for the particular region under investigation. The level of the valley to which the observations are reduced, as a base, is about 570 meters above the sea level. The observations were made at Innsbruck in the years 1863–1878, by the father of the author of the paper, and forms a complete series for both northern and southern exposures. In the principal table there is given (for both exposures) for each day of the year: the mean elevation, the maximum elevation and the year when it occurred, the minimum elevation and the year when it occurred, the amplitude, the number of years with snow down to 570 meters, the number of years of observation.

There is also given for each day of the year, for the south exposure only, the average values with the exclusion of the four highest and four lowest observations, and this mean of the seven or eight years used is called the "mean of the central half of the years" or the "central mean"; and also the means of the five highest and lowest values called the "central limits," and the amplitude. H. Denzler in his work on the observations made by J. Zuber on the snow limits for the northern side of the Alps, from Lake Geneva to Sântis (1821–1851), mentions the importance of this "central mean" (inneres Mittel), but did not carry out the computations of this work.

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*Untersuchungen über die Schneegrenze im Gebiete des mittleren Innthales. von Fritz Ritter Kerner v. Marilaun. Aus dem *LIV* Bande der Denkschriften d. Kais. Akad. d. Wissenschaften. Wien. 1887.

The following table of monthly means is of interest:

Month.	Elevation of Snow Limit Above Sea Level.		Difference Between N. and S. Exposures.
	South Exposure.	North Exposure.	
Dec.	741m	680m	61m
Jan.	647	592	55
Feb.	738	598	140
Mar.	960	722	238
April	1267	1106	161
May	1699	1543	156
June	2192	2029	163
July	2677	2467	210
Aug.	3127	2932	195
Sept.	3207	2761	446
Oct.	2154	1890	264
Nov.	1303	1007	296

This paper of 61 quarto pages, with 1 plate and 11 wood-cuts, gives a complete discussion of the data used, and it seems to the reviewer that it forms an excellent model for similar works.

F. WALDO.

THE GOVERNMENT OBSERVATORY AT BOMBAY, under the direction of Charles Chambers, Esq., F. R. S., has recently issued its twenty-seventh volume of magnetical and meteorological observations, relating to the year 1886. The observatory is at Coliba, situated on the harbor a few miles from Bombay. The present report contains careful descriptions of the instruments employed, the means, maxima and minima of the automatic registers of the usual meteorological and magnetical elements, also five-day means for 1886, and annual and lustral means for 1881 to 1886. There are six appendices relating to magnetical subjects, of which the most interesting is that relating to the luni-solar variations of declination and horizontal force. Mr. Chambers finds that the luni-solar variations can be very closely expressed by a formula which a diurnal harmonic of which the amplitude varies from day to day during the season.

THE CLIMATE OF BELGIUM.*—This little volume of 79 pages, extracted from the "Annuaire de l'Observatoire Royal de Bruxelles pour 1888," contains averages of the meteorological obser-

* Le Climat de la Belgique, en 1887. Par A. Lancaster.

vations made at Brussels, arranged for each month of the year; charts, showing ten day periods of the temperature and barometric pressure at Brussels; and monthly résumés of the climate of Belgium (Brussels and a few other places). Taking Brussels as representative of Belgium, the following table will give a good idea of the climate:

	Normal values or extremes.	1887.
Mean barometer hight at noon.....	756.2 mm.	757.1
Greatest mean barometer hight....	759.3	.....
Least " " "	753.7	.....
Mean temperature for the year.....	10.3°	9.1°
Greatest mean temperature for the year.....	12.1°	.....
Least mean temperature for the year.....	8.8°	.....
Absolute maximum temperature..	35.2°	32 8
Absolute minimum temperature...	—20.2°	—9.2
Mean number of days with frost...	48	71
Max. " " " " " ...	91	.....
Min. " " " " " ...	9	.....
Prevailing winds (prop. to 100)...	S.W. (30), W. (17) S. (12), E. (11)	S.W. (25), N.E. (14) W. (14), E. (13).
Humidity at noon.....	74.1	72.6
Mean evaporation of a day.....	2.3 mm.	2.2 mm.
Total evaporation of a year.....	834.	797
Rainfall.....	679	560
Melted snow.....	52	62
Precipitation.....	731	622
" Max.....	1046	.....
" Min.....	449	.....
Days with precipitation.....	195	184
" " rain.....	188	187
" " snow.....	25	42
" " hail.....	11	14
" " thunder.....	17	11
" " lightning and thunder.	6	4
" " fog.....	63	58
Cloudy days.....	36	36
Clear days.....	9	5
Mean cloudiness.....	6.7	6.6

The year is counted from December to November, inclusive.

F. W.

THE MARITIME CONFERENCE.—An act of Congress, approved by the President July 9, 1888, provided for an International Maritime Conference to secure greater safety for life and property at sea. Invitations were accordingly extended to each maritime nation to send one or more delegates to meet in Washington April 17, 1889, as was stated on the *Pilot Chart* of last September. Owing, however, to unexpected delay in receiving the responses of important maritime countries, and in view of the limited time remaining within which to prepare the program of the subjects to be brought before the Conference, and to communicate the same to the several Governments for their information and use in instructing their delegates, the President has deemed it advisable to postpone the meeting of the Conference until a later date. The various Governments invited to participate in the Conference have been notified accordingly, and this delay will permit the seasonable completion of the necessary preliminary arrangements.

STUDY OF OCEAN CURRENTS.—With characteristic enterprise, the Division of Marine Meteorology of the Hydrographic Office has formed a plan for the systematic study of ocean currents by means of floating objects thrown from our men-of-war. These objects are to contain a paper in six languages, giving the heading, time of throwing overboard, time of finding, and directions for forwarding the find to the Hydrographic Office. The paper is unusually neat, compact, and easily understood.

CLIMATE OF BELGIUM FOR 1888.—Mr. A. Lancaster's attractive annual account of the climate of Belgium, of 92 pages, duodecimo, with several graphic representations of the progress of the elements, and many tables, makes a model which some one ought to follow in this country. This is published as a part of the *Annuaire* of the royal Belgium observatory, of which Mr. Lancaster is meteorological inspector.

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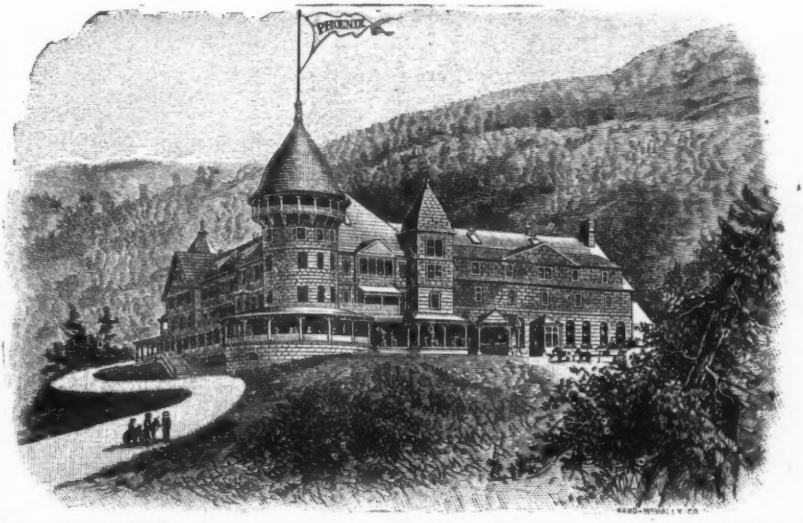

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